ECOLOGICAL STATUS AND REGENERATION PATTERNS OF *JUNIPERUS EXCELSA* FORESTS IN NORTH-EASTERN BALOCHISTA.

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Abstract

Juniper (*Juniperus excelsa*) form the dominant tree covers over large parts of north-eastern part of Balochistan. Thirty stands in different forest zones were randomly sampled quantitatively during summer in 2012-2013. Phytosociological attributes such as the floristic composition, density ha^{-1} and basal area $m^2\ ha^{-1}$, size class distribution are presented. In total, 37 species of shrubs, herbs and grasses were recorded. Density of juniper trees (> 6 cm dbh) ranged from 106 to 379 individuals ha^{-1} with an overall mean of 243±42 individuals ha^{-1} while the average basal area was 73±33 $m^2\ ha^{-1}$. Highest seedling density of 439 individuals ha^{-1} was observed from Zizri Tore Sagran site, at elevation of 2948 meter on west facing slope. Size class distribution showed varied distribution patterns with gaps appearing in the large size classes in different stands. Present study shows that each and every Juniper stands are highly disturbed mostly due to human disturbances *i.e.* illegal cutting and overgrazing. Natural pressure as low regeneration, fungal disease, mistletoe, soil erosion and effects of climatic change were also responsible for degradation of this forest. Therefore, prompt conservational steps should be taken to safe these forests for the future generations

Introduction

Juniperus excelsa M. Bieb (Cupressaceae) grow in different parts of the world from North America, South East Europe, East Africa, Middle East, Central Asia, South Asia to Himalayan regions of China, India and Pakistan (Farjoon, 1992). The genus *juniper* is the second most diverse group of the conifers consists of about 67 species while only five species are available in Pakistan (Adams, 2008). It is listed as a threatened tree by IUCN Red List in Pakistan (Anon. 2006). *J. excelsa* is an evergreen giant shrub or tree up to 20 m, as large as two m diameter at the (dbh). Juniper forests and connected diversity of plants and animals compose a distinctive ecosystem in the arid and harsh climatic conditions in Baluchistan. These forests are ecologically and economically significant, larger, famous and unique forest of the world and fulfill the needs of local communities in the form of fuel wood, fodder for livestock, fencing material, barks for thatching of huts, building, protect soil erosion, and recharge the underground water table. There have been only few studies concerning the structure and regeneration patterns of *J. excelsa* stands in the overall area of the species extension (Ahmed *et al.*, 1989; Fisher and Gardner 1995; Gardner and fisher 1996; Carus, 2004). However, Khattak (1963) presented working plan while Rafi (1965) described various vegetation types of Baluchistan. Champion *et al.,* (1965) described these forests qualitatively and included under dry temperate area. Sheikh (1985) suggested a forestation while Ahmed *et al.,* (1989) explored natural regeneration in this forest. Wahab *et al.*, (2008) carried out phytosociology and dynamics of some pine forest of Afghanistan, close to the Pakistani border similarly; vegetation structure of *Olea ferruginea* forest of lower Dir was presented by Ahmed *et al*., (2009). Siddiqui *et al.*, (2009) carried out phytosociology of *Pinus roxberghi*i in lesser Himalayan and Hindu Kush range of Pakistan. Vegetation structure and dynamics of *Pinus gerardiana* forests of Zhob district of Baluchistan were also studied by Ahmed *et al.,* (1991). Ahmed *et al* (1989, 1990) and Sarangzai (2001) investigated population structure and regeneration potential of *Juniperus excelsa* forest in Balochistan. Recently ecology and dynamics of this species was presented by Sarangzai *et al.*, 2012c). They also showed and described various physical conditions of Juniper trees. Ahmed *et al.,* (2010) and recently Ahmed and Shaukat (2012) and Sarangzai *et al.,* (2012a, b) reviewed status of vegetation analysis and ethno botany of Juniper in Pakistan. Due to human and natural pressures such as over grazing, illegal cutting, debarking of juniper trunks, branch cutting, and fuel wood collection and for hedges of sheepfolds, deficient in rain fall and periodic drought are the many major reasons. In this context, the aims of the present are to study quantitatively the ecological status and regeneration patterns of some Juniper forests in Balochistan.

Study area: Ziarat derives its name from Shrine (Ziarat) of Baba Kharwari located at a distance of about seven kilometer in the south of Ziarat town. Ziarat is located in the north-eastern region of Balochistan, with an area of 347,200 square kilometers. The whole sampling area occur at elevations between 1980-3,350 meters and geographically extended between Latitude 30° 18' N to 30° 30' N and longitude 67° 54' E to 67° 57' E (Fig. 2). Koh Khalifat (3, 475 m) is the highest mountainous peak of the area under study. The study area indicates the dry temperate climate and pleasing summer and extreme cold during winter (Champian *et al*., 1965 and Holdrege, 1947). Regular snow falls and frosts were found from December to March (Khattak, 1963). About 282 millimeter/yr annual precipitations were received (Ahmed *et al.,* 1990). Eighty two centimeter snow fall were reported as the highest in February 1977. In July and August some showers also occur. Mean minimum temperature -9 C° in January and mean maximum temperature 28 C° in July and August were recorded in the study area. The average percent humidity was reported as highest 67% and lowest of 23 % (Fig 1).

Material and Methods

Thirty stands in various Juniper forests of Baluchistan were quantitatively sampled using point centered quarter method (PCQ) of Cottom and Curtis (1956) in the different forests zone of Ziarat district. At each area at least one hectare area was included and global position system (GPS) was used to locate these sites on the map. Elevation, aspect, slope angle, and were recorded. Juniper trees greater than 6 cm dbh (Diameter at the breast height) were selected for sampling. Following Ahmed and Shaukat (2012), 20 points were taken at each stands at every 30 meter intervals along transect in a stratified random way. Point to plant distance and diameter of tree within the sampling point was recorded. Seedlings density and ground flora were recorded using circular plots of (1.5 meter diameter). Species identification was followed by Stewart (1972).

Density size frequency histogram for each location was constructed. Diameter size-class frequency distribution of *J. excelsa* trees (> 6) and seedlings (< 6 cm dbh) were obtained size structures of juniper seedlings/trees are presented using MS Excel 2003. In addition, tree size classes divided into four categories, i.e; small size classes (10 to 30 cm dbh), middle size classes (40 to 60 cm dbh), large size classes (70 to 90 cm dbh) and above (90 cm dbh) extra large size classes. Diameter of the trees measured at the breast height (1.3 meter or 4.3 feet above ground floor).

From each stands soil samples were collected and analyzed in the laboratory. Organic matter, water holding capacity and $CaCo_3$ was obtained following Ahmed (1970).
Regressions analyses were performed to see relationships between tree density and basal area, stand density and seedling density, stand basal area and seedling density.

Results and Discussion

Detail sites, elevations aspects latitude and longitude, slope, canopy, of each stand of the study area is given in the Table 1.

Density and basal area: Density and basal area values for both juniper trees and seedlings across 30 stands of the study areas are summarized in (Table 2 & 3). Highest stand density values of 379 individuals ha^{-1} was recorded from Kotal Sari Malicut site at elevation of 2630 meters on north-east facing slopes, followed by 367 individuals ha^{-1}, Pila forest Markhazai site at the elevation of 2680 m on the north facing slope. Howeve, at Chasnak Aghbourg and Nishpa valleys also represented higher densities respectively (Table 2). The overall stem density of juniper trees (> 6 cm dbh) recorded were 243±42 individuals ha^{-1} with a range from 106 to 379 individuals ha^{-1}. The basal area of *J. excelsa* trees were varied greatly, not only between the elevation and aspect, but also among the stands of the same sites. The basal area values were found lowest for the Chasnak Aghbourg site and highest for Zizri site respectively. They were ranged from 26 -121 m^2 ha^{-1} with an overall mean basal area of 73±23 m^2 ha^{-1} (Table 2). The basal area did not differ between north and west facing slopes but tree density was higher on north- west and south west facing slope. Density of juniper trees was strongly correlated with tree basal area r= 0.38 **(**$P < 0.001$) (Table 4).

The contribution of juniper regeneration was also varied considerably both between and within sites. They were recorded in 27 stands out of 30 stands. Highest seedling density 439 individuals ha^{-1} were observed from stand Zizri Tore Sagran site, at elevation of 2948 m on west facing slope while the lowest density 99 individuals ha^{-1} was recorded from stand Nishpa valley, at elevation of 2639 m on west facing slope. The overall mean seedlings density recorded was 215 ± 78 individuals ha^{-1} (Table 3). The average basal area for all stands was area 67±21 cm^2 ha^{-1} ranging from 99 to 143 cm^2 ha^{-1}. Some stands with similar basal area values had quite different densities while in some cases reverse were the case. Stand basal area with seedling density area were negatively correlated = 0.28 ($P > 0.05$) and non-significant (Table 4).

During the circular plot sampling 37 associated species of shrubs, herbs and grasses were recorded across all the stands of the study area. Taxonomically 18 families, 3 monocot (6 species), 14 dicot (30 species) and 1 Gymnosperm (1 species) were recorded. Based on the mean relative frequency valves, *Berberis baluchistanica* was found dominant among shrubs, followed by herb *Iris stocksii* while *Stipa himalaica* was most abundant among grasses. The overall mean relative frequency values result revealed that, in reported flora (51 %) were herbs, shrubs (39 %) whereas grasses were recorded (10%) in all stands of the study area.

Size class frequency distribution: Size structure diagrams for juniper trees (> 6 cm dbh) were prepared for selected sites of the juniper forest (Fig. 3). All stands are composed of mosaics of mixed size classes. In many stands the size class distribution is positively skewed that shows that density gradually decreases to large classes and some are unimodal and shows that density increase in middle classes while other site showed more than one mode. Low density stands had flatter structure, often with several modes. Stands with moderate density normally formed intermediate size class frequency distribution. The combine data show a balanced size class structure. Results shows 60 % of the trees were found in the small size classes (classes 1-5) Density decreased with increasing size classes**.**

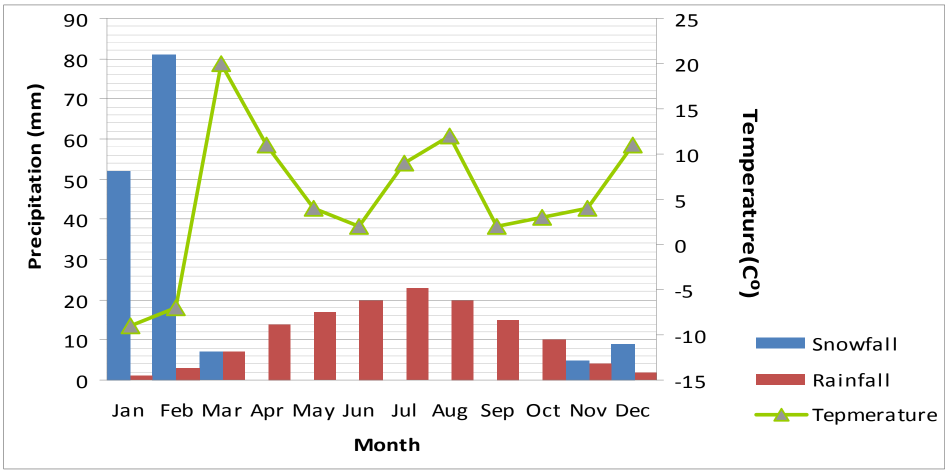

Fig 1: Ziarat mean monthly temperature, mean Monthly Rainfall and snowfall.

Fig 2: Map of study area of **Ziarat Juniper forests in Balochistan. (cameo)**

The size class frequency distribution of seedlings (< 6 cm dbh) shown in (Fig.4) that most of the stands are composed of mixed size class and in these stands individuals are found in small size classes with gradual decrease in bigger size classes. Some stands have similar number of seedlings per hectare but show different size structure. Most of the stands show one or more gaps due to the absence of seedlings of the particular size classes (Fig 4). These gaps have been frequently observed in the population structure but the reason of these gaps not yet been explored. Absence of seedlings in particular size class indicates either lack of regeneration or mortality during the particular period or year

Table 1. Ecological characteristics of sampling sites and stands of the study area.

	Main Location		Latitude (N)	Longitude (E)	Elevation (m)	Slope (o)	Exposure
1	Zizri Area	ZA	30° 20'	67° 42'	2948	45	W
2	Baba Kharwari	BK	30° 20'	67° 49'	2645	36	NW
3	Kotal Sarri	KS	30° 22'	67° 48'	2630	29	NE
4	Cautair Valley	CV	30° 25'	67° 47'	2600	37	S
5	Nishpa Valley	NV	30° 17'	67° 59'	2639	46	W
6	Pila Forest	PF	30° 25'	67° 37'	2740	30	NE
7	Sasnamana state forest	SF	30° 24'	67° 49'	3116	38	NE
8	Chasnak Aghburg	CA	30° 27'	67° 41'	2880	30	SE
9	Surghund	SG	30° 20'	67° 50'	2510	29	W
10	Spera-Ragha	SR	30° 31'	67° 14'	2695	42	N

Table 2. Summary of tree density and basal area values from 10 main locations in the study area.

	Elevation(m)	Exposure	Density (ha^{-1})			Basal area (m^2ha^{-1})		
			Min	Max	Mean±SD	Min	Max	Mean±SD
Zizri Area	2948	W	219	307	263±62	71	119	95±34
Baba- Kharwari	2645	NW	176	321	249±103	36	97	67±43
Kotal Sarri	2630	NE	122	379	251±182	25	38	32±9
Chautair Valley	2600	S	126	223	175±69	28	104	66±54
Nishpa Valley	2639	SW	239	337	288±69	58	73	66±11
Pila Forest	2680	N	162	367	265±145	91	151	121±42
Sasnamana state forest	3116	NE	118	279	199±114	36	124	80±62
Chasnak Aghburg	2880	SE	152	356	254±144	32	96	64±45
Surghund	2510	W	286	311	299±18	58	77	68±13
Spera-Ragha	2695	N	106	272	189±117	26	115	71±63
Overall mean values					**243±42**			**73±23**

Table 3. Summary of Seedlings densities and basal area values from 10 main locations.

Main locations	Elevation(m)	Exposure	Density (ha^{-1})			Basal area (cm^2ha^{-1})		
			Min	Max	Mean± SD	Min	Max	Mean± SD
Zizri Area	2948	W	326	439	383±80	32	44	38±8
BabaKharwari	2645	NW	156	269	213±80	48	82	65±24
Kotal Sarri	2630	NE	142	255	199±80	62	108	85±33
Chautair	2600	S	0	198	99±140	0	67	34±47
Nishpa Valley	2639	SW	99	340	220±170	42	143	93±71
Pila Forest	2680	N	241	312	277±50	42	62	52±14
Sasnamana area	3116	NE	156	354	255±140	40	91	66±36
ChasnkAghburg	2880	SE	127	184	156±10	58	125	92±47
Surghund	2510	W	184	198	191±10	58	76	67±13
Spera-Ragha	2695	N	99	212	156±80	21	143	82±86
Over all mean					**215±78**			**67±21**

Table 4. Relationships between Juniper tree density/ basal area, with seedling density on soil variables in the study area.

S. No	Variables	Regression equation	r	Significant value
1	Tree density/basal area	y = 0.1603x + 38.105	0.38	***
2	Stand density / Seedling density	y = 0.1418x + 237.45	0.70	NS
3	Stand Basal area / Seedling density	y = 0.0897x + 60.565	0.28	*
4	$CaCO_3$ / Tree density	y = -2.4343x + 291.56	0.08	*
5	Water holding capacity / seedling density	Y = 0.0163 x + 32.94	0.197	**
6	Organic matter / seedling density	Y = 0.0005 + 3.296	0.092	NIL
7	Altitude / seedling density	Y = 0.2228 x + 2674.3	0.145	NIL

Note: r = multiple r-value; NS= non-significant; Significant level * =p<0.05; ** =p<0.01; *** p=0.001

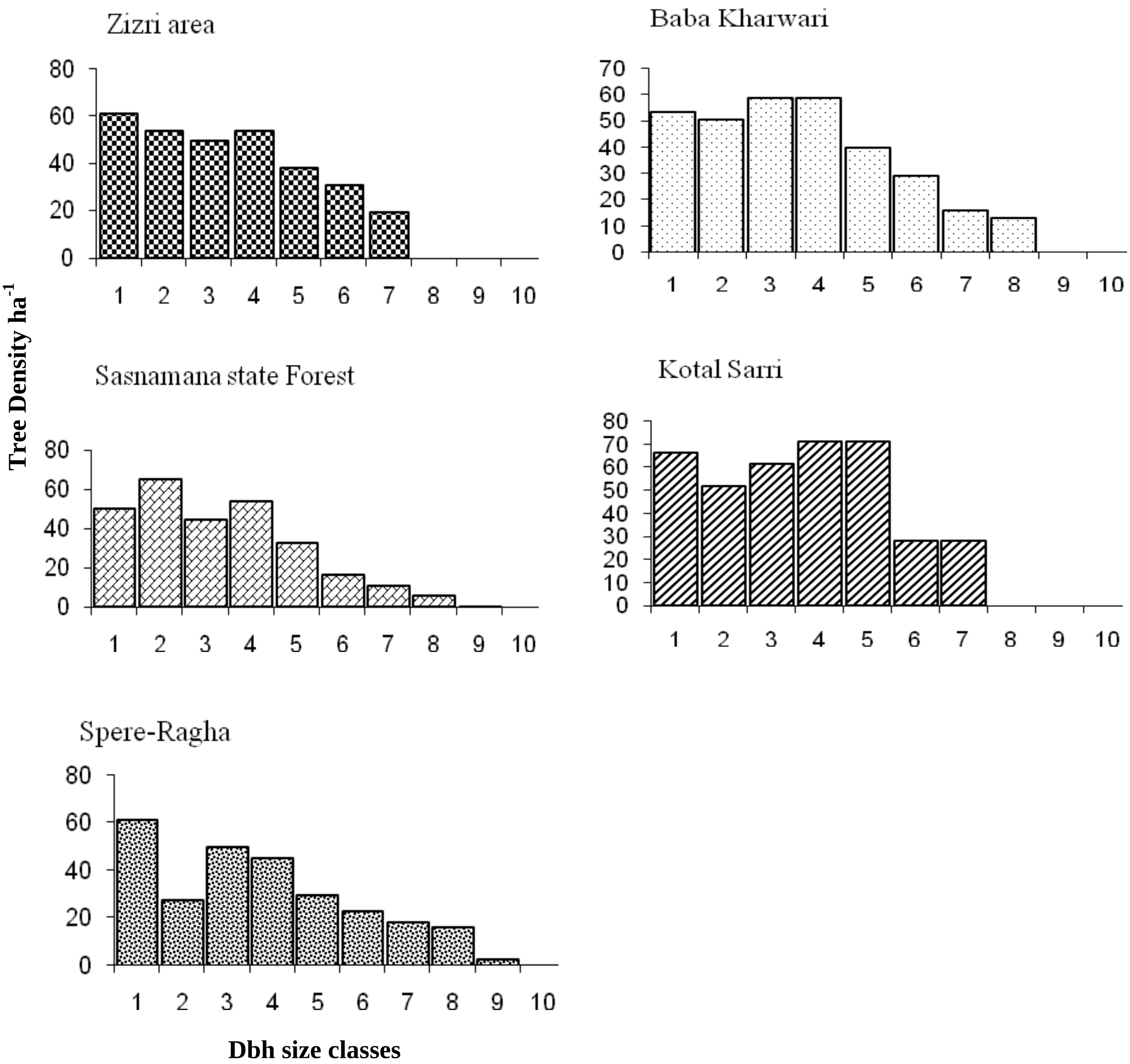

Fig 3. Juniper tree (> 6 cm dbh) **size-class structure of few selected sites in the study area.**

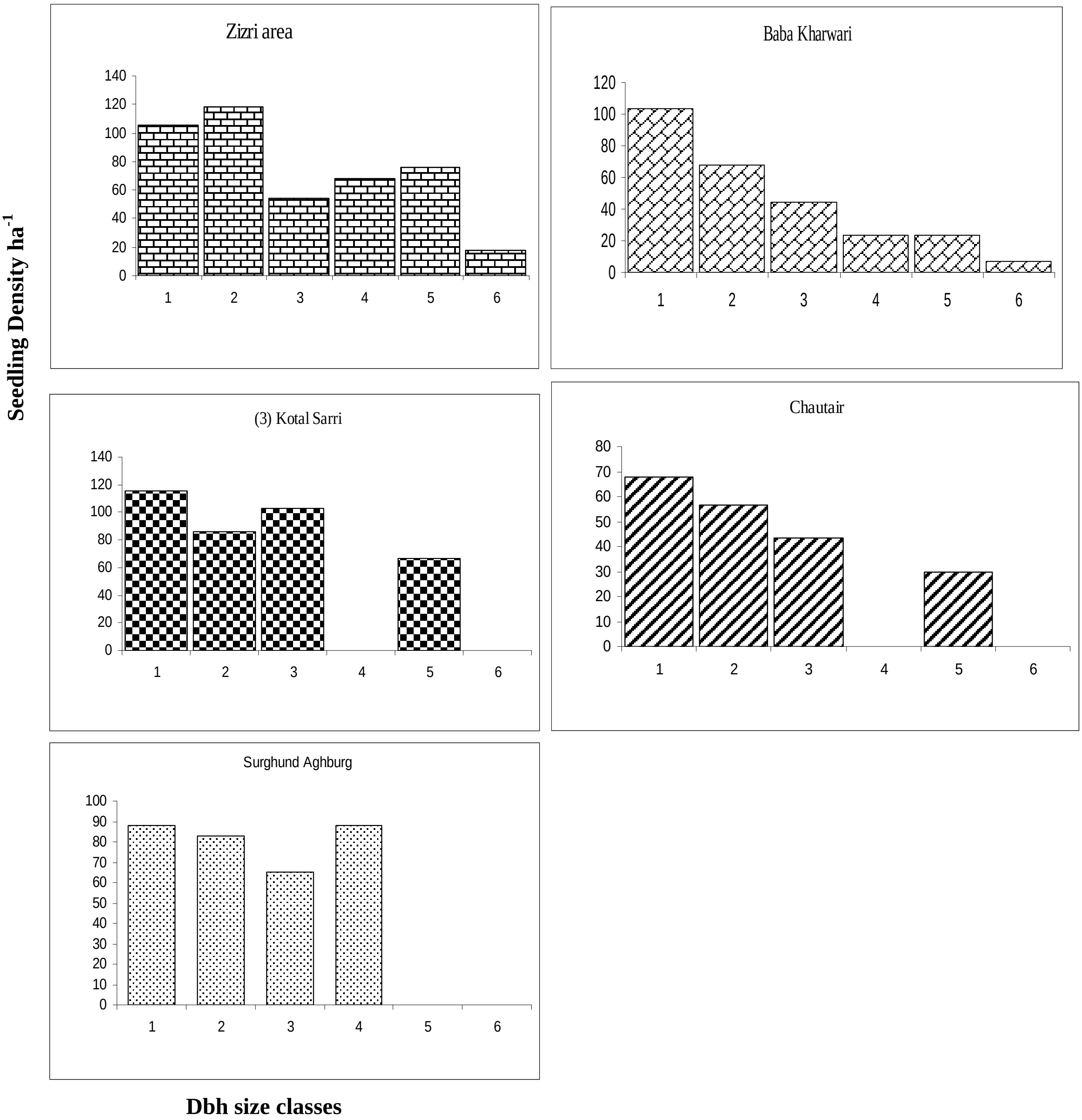

Fig 4. Juniper seedlings (< 6 cm dbh) **size class structure of few sites locations in the study area**

Discussion

Plant conservation status can be evaluated and analyzed by thorough vegetation analysis of a specific area under study that provide immense information of its structure, composition and dynamics (Rawat *et al*., 2012). *J. excelsa* forms open and un-stratified stands in the area studied. Anthropogenic effect such as deforestation i.e cutting for fuel wood and overgrazing and over collection of plants has changed the vegetation composition and regeneration of plants specially junipers of the studied. Many deciduous trees such as *Fraxinus xanthoxyloides* a widely distributed species of dry temperate areas in Pakistan (Ahmed, 1988c) is now completely eliminated from this forest. However, few trees still exist along the water courses (Sarangzai, 2000). At present, 37 species of herbs, shrubs and grasses were associated with juniper forest while 24 species were reported by (Shafeeq, 1987) from Ziarat Juniper forest area. Site to site variation in the data showed that stem density might depends on various environmental, edaphic and topographic factors (Ahmed, 1984). With the few exception at the lowest altitude (Nishpa valley and Spra-ragha area), it was found that density and basal area diversity of both Juniper tree and seedlings were greater on the north and north-east facing slope than on the south facing slope. It is observed that the higher soil moisture, higher organic matter content, better habitat conditions and longer growth period encouraged the greater density and basal area of the tree population on the north facing slope (Sarangzai, 2000).

The average density ha^{-1} of juniper trees across all the stands in the present study varied greatly from 106 to 379 individuals ha^{-1} with an average of 243±42 individuals ha^{-1} and this was relatively higher compared to juniper tree density 54 to 154 ha^{-1} from juniper forest of Rodhmallazai area (Ahmed *et al.,* 1990 a & b). In comparison to these near by forests, in the previous study, the density was also ranged from 88 to 376 individuals ha^{-1} with an average of 214±65 individuals ha^{-1} (Sarangzai, 2000). Similarly, ***Pinus gerardiana***, a dry temperate forest of the Zhob district showed average density 226 ha^{-1} with a range of 24 to 930 trees ha^{-1} (Ahmed *et al.* 1990a). The overall mean basal area of present juniper tract was higher 78±33 m^2 ha^{-1} than the reported for juniper tract (41 m^2 ha^{-1}) and *P. gerardiana* forest (25 m^2 ha^{-1}). The differences are explained by on the basis of earlier estimation of the entire Juniper tract, where our average 243 individuals ha^{-1} refers to 30 random mature Juniper stands the areas. Thus this dry temperate forest was not poor in stem density and basal area as compared to other forests. The present investigation of the density and basal area values obtained shows similar results as previous findings in Pakistan**.** Similar density and basal area values are available from sub tropical and moist temperate zone; density of *Olea ferruginea* was recorded 378 individuals ha^{-1} with 16 m^2ha^{-1} basal area, in *Quercus incana* community under broad leaved forest. Some other published data, (Ahmed *et al* ., 1991) of other forest in Pakistan is also available for comparison. In moist temperate mixed forest**,** deodar attained 433 ha^{-1} density with 78 m^2ha^{-1} basal area while 148 individual ha^{-1} and 83 m^2ha^{-1} basal was recorded from a moist temperate conifer forest (Ahmed *et al.,* 2006)**.** The variability of Juniper trees and seedlings/saplings density as found in the study area is primarily linked with human activities and environmental conditions and to lesser degree with the physiographic factors (Ahmed *et al.,* 1990).. Human population has an impact on the habitat of Ziarat and as a result the greater intensity in cutting and overgrazing has presumably affected the juniper stock density. In the present study, the density and basal area of juniper seedlings were found great variability not only between sites and elevations but also on various aspects might be the consequences of slow growth rate, removal of wood, berries and other human disturbance. (Sheikh, 1985) reported that the juniper forests of Balochistan are incapable to rejuvenate, may be due to lack of natural regeneration. Poor sapling establishment, hard seed coating, effects of seed sucking insects and frequent destruction of trees due to fie and diseases. In contrast to the earlier reports, the present would strongly suggest the regeneration occurs in mature juniper stands. In the present study, the stands have seedling population ranging from zero to 439 ha^{-1} with an average of 194 seedlings ha^{-1}. Sarangzai *et al.*, (2000) and Kambiz *et al.*, (2012) reported seedling density and basal area is higher where conditions are favorable and regeneration neither of seedlings generally not deteriorating nor in an unstable state.

A similar large number of seedlings were found during the present study, either under the tree canopies or in the adjacent areas of the parent trees. Ahmed et al (1989) argued that Juniper seedlings require shade in their early stages of development; therefore, they suggested that exposed soil surface, distance between juniper trees and low vegetation cover with over grazing were the main factors responsible for lack of natural regeneration in the study area. In addition, in few plots no seedlings from completely logged or eroded sites suggested that seedlings require shade or better soil conditions (or both) in the early stages of growth. Such situation has also been reported for other tree population (Ahmed, 1984).A positive correlation ($P <.05$) between stand basal area and seedling density ha^{-1} would suggest that juniper seedlings are shade loving in the early stage of seedling development as reportd by Ahmed et al (1989). Despite the continued disturbances in the area, the size class structure in many juniper stands is normal and a sufficient number of individuals in small size classes are available. Despite variations in individual stand structure, overall size class structure *J. excelsa* trees had higher density in small size classes with gradual decrease in large size classes. According to Knight (1975) this pattern of population structure indicates adequate recruitment. In addition, overall seedlings/tree size class structure showed higher number of young trees compared to established seedlings, indicating that *J. excelsa* could be referred as fair producers, as concluded by Saxena & Singh (1982). Gaps in size class structure were due to cutting rather than failure of regeneration. It is likely that if some of these stands are regulated or properly managed, natural regeneration will be increased.

In Pakistan these gaps have never been studied and most of the conclusions are based on the study of disturbed forests. It is suggested that gap in the middle, may result from tree fall by storm or cutting while in the beginning at the sapling stage, these gaps may be due to the grazing of young seedlings (Ahmed, 2009). In many stands, smallest size class showed no or very small number of trees. This situation may controlled by promoting regeneration in the stands. The present study shows great number of seedlings (< 6 cm dbh) and individuals in a small size class (1-5 cm dbh) in mature Juniper forests. One of the reasons of reduced seedlings in some areas may be because of over grazing by animals. Generally in unbalanced forests**,** dead trees are not been replaced by nearly equivalent younger trees. Cameron (1954) emphasized that seedlings of some light demanding dominant trees cannot grow in dense canopies thus crating a regeneration gap. It is assumed that gaps in the structure do not necessarily mean that the particular size class is absent from the stand or is due to a failure of regeneration at some time in the past. In these stands large numbers of juniper seedlings were also recorded**,** indicating a balanced population structure**.** Though large trees are removed from the area, these forests can be managed and protected easily**.** Due to some disturbances and difference in microclimate, poor floristic composition was being observed in many stands. Many stands showed gaps in small size classes with flat size structure indicating no recruitment or cutting of small sized trees**.** These unbalanced populations need more attention to save and protect these forests**.**

Conclusions and Recommendation

The present study has revealed that some parts of the Ziarat Juniper forest in Balochistan are under severe threat of extinction because of degradation due to several biotic and physical factors. It is concluded that each stand is disturbed, unstable and showing varied size distribution. Most of the forest area have low seedlings, young trees and shows no adequate recruitment. Anthropogenic disturbances i.e; illegal cutting, overgrazing, periodic drought, low regeneration, variation in size classes, slow growth rate, low density, higher numbers of unhealthy and over mature trees and lack of correlation between Juniper density and basal area. Most of the stands of Juniper population is evidently appears to be disturbed. Over mature, open, fragmented which resulted in isolated patches of these forests. Therefore, it is suggested that suitable conservative and management practices would save these forests for future generations.

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